FOREST BIOLOGY DIVISION, SCIENCE SERVICE, CANADA DEPARTMENT OF AGRICULTURE

SOME FOREST INSECT and DISEASE PROBLEMS of CANADA

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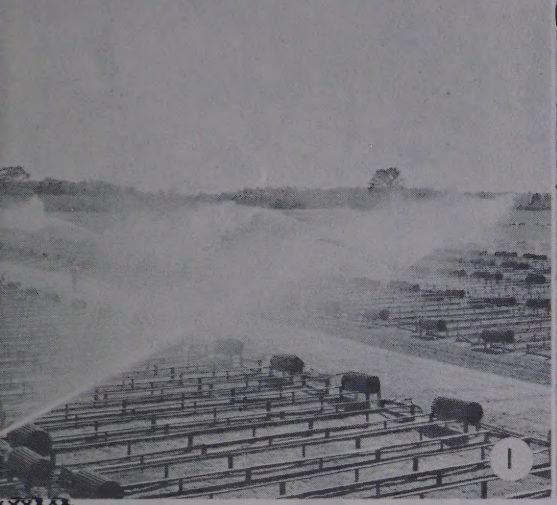
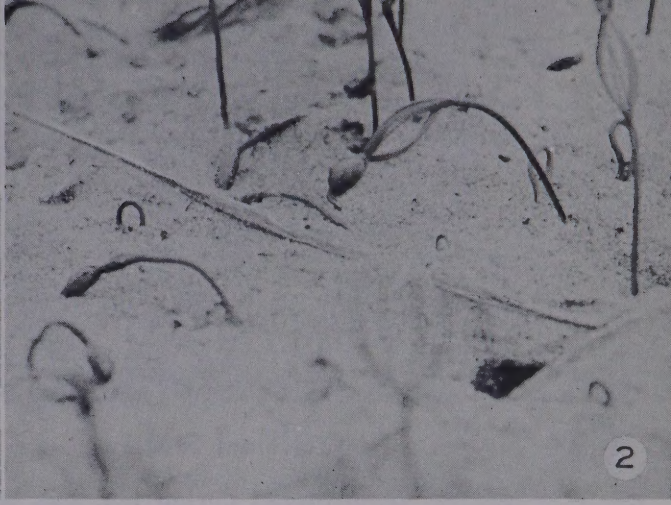
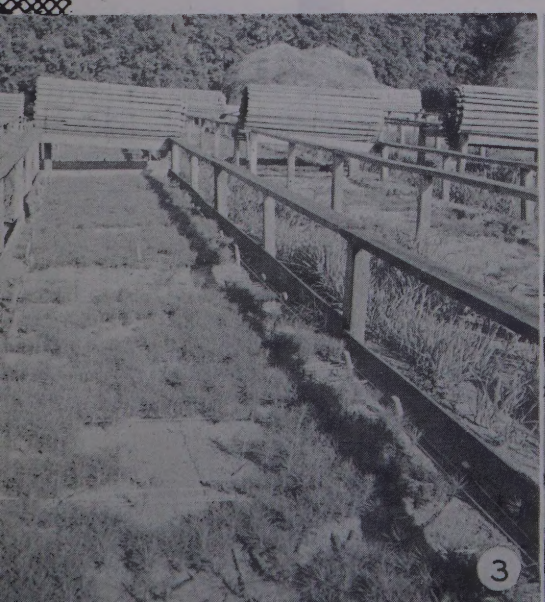
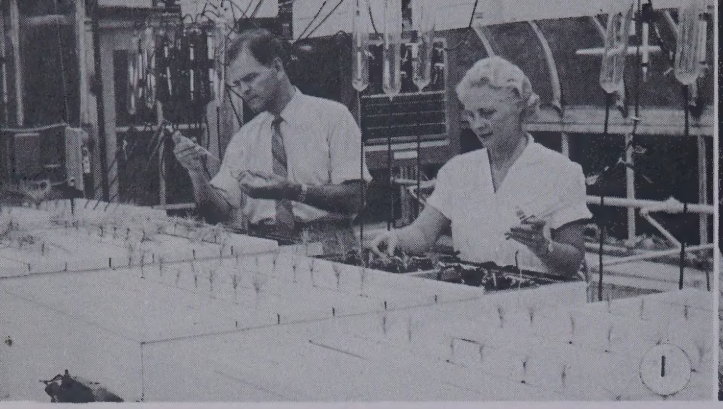


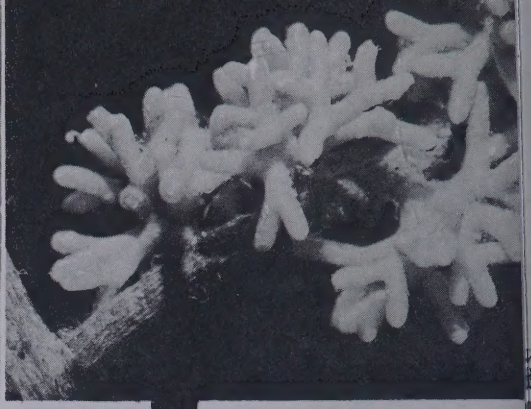


1 Seedling Diseases

Large numbers of seedlings (1) are required to sustain the reforestation programs in Canada. The damping-off disease (2,3) causes heavy losses of Douglas fir, white spruce, and red pine seedlings in the forest nurseries of British Columbia, Saskatchewan, and Ontario. Research on the biology and pathogenicity (4) of several organisms is being done to find an explanation for the sporadic and destructive occurrence of seedling mortality. Work is being done on the prevention or reduction of damage by cultural methods aimed at rapid, vigorous seedling growth and a decreased incidence of disease pathogens. Attention is also given to the possibility of biological control through the use of parasitic fungi and antibiotics. Other studies include nutritional and physiological problems which arise from adverse soil conditions.



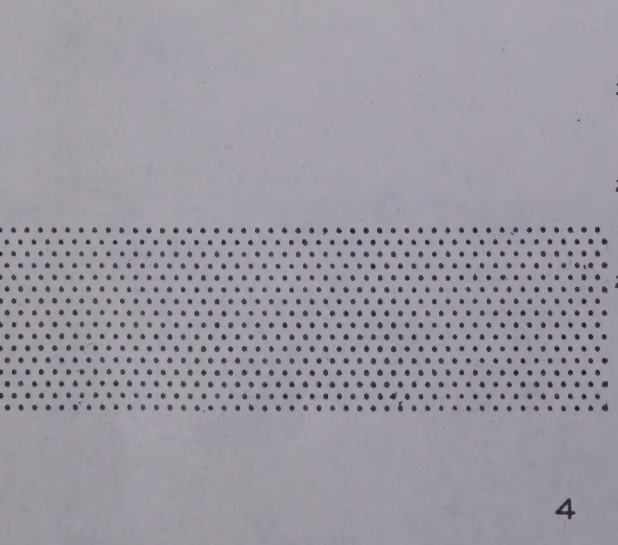


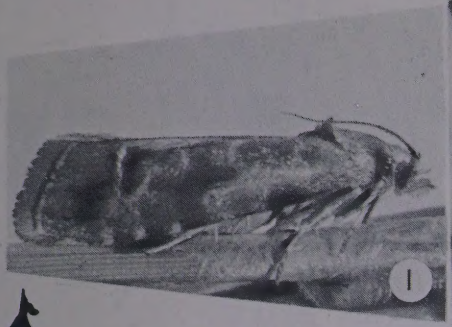


Mycorrhizal Studies

Evidence accumulated during the last 30 years has proven that mycorrhizal fungi act in a symbiosis with roots, which is beneficial and under certain circumstances necessary for the growth of trees. Recent discoveries have shown that mycorrhizal fungi act not only as nutrient absorbing agents for the tree but, in symbiosis, exude substances related to auxins. These substances cause roots to swell and branch extensively and thereby increase the absorbing surface of every mycorrhizal root (1,2).

In Ontario fundamental studies are in progress to discover the nature and effect of exudates, and the influence of light, temperature, and nutrition upon the production and composition of these exudates from both symbionts. Practical application of the present knowledge of mycorrhiza includes the fertilization of nursery soils with forest duff containing mycorrhizal fungi, and the introduction of synthetic auxins to the root systems of seedlings at the time of transplanting. Figure 3 shows the difference between control and auxin-treated seedlings one year after transplanting. Figure 4 compares the root development of seedlings grown in ordinary nursery soil and soil fertilized with duff from a coniferous stand. Preliminary results suggest that it may be possible to reduce the time required to produce planting-out stock. Greater survival may be expected in the field since their root systems possess better mycorrhizal development.

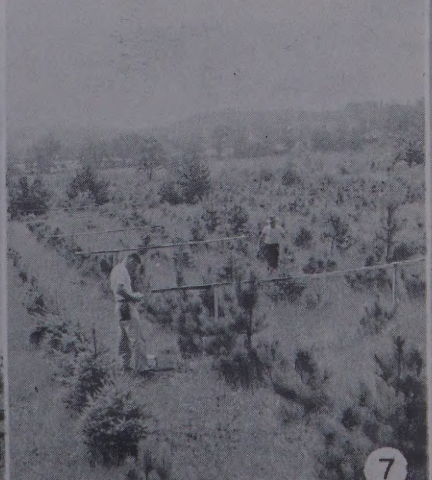


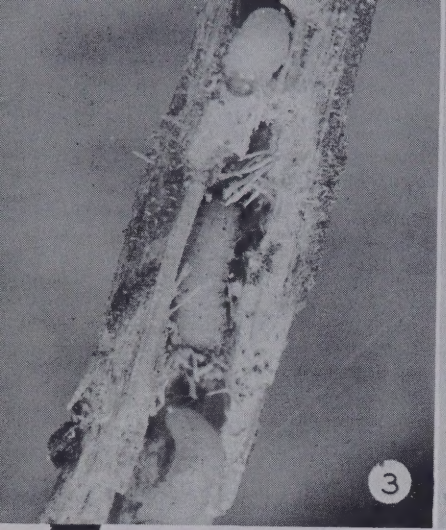


European Pine Shoot Moth

Nursery stock has been the medium of introduction much of the spread of this insect in Canada. Al-ıgh found in other provinces, only in southern Ontario it become a serious problem. All species of pine are ıcked but red and Scots pine are preferred. The moth deposits eggs in June and July on the needle sheath or ot tip. Young larvae (2) feed first on the needles near sheath and later enter the buds where they overwinter. the spring they feed on new buds and developing ots, pupating in the latter. Feeding sites are charac-ızed by an accumulation of webbing and pitch. Pupae trude from these masses to aid moth emergence (3).

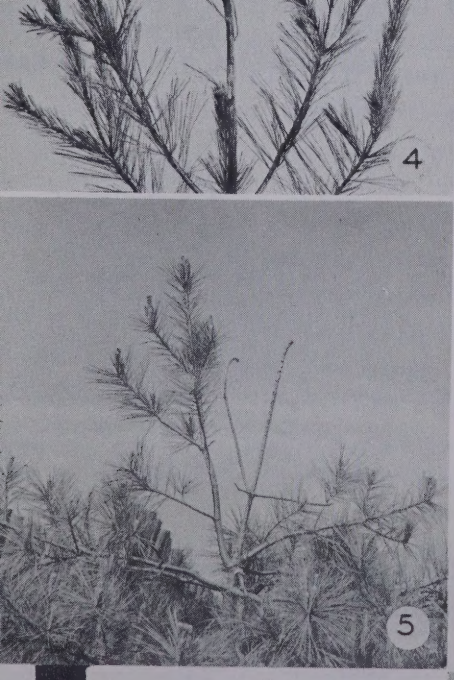
Plantations are susceptible to injury until the e of crown closure. Repeated bud killing causes nting and multiple leader development (4,5). Feeding one side of a developing shoot produces a distorted m (6). Hand picking of infested shoots, and heavy ecticide applications at oviposition time, are means control. Methods of spray application are being studied 8) to determine more satisfactory control measures.

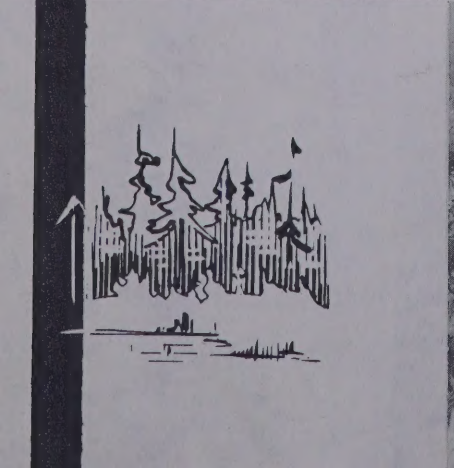


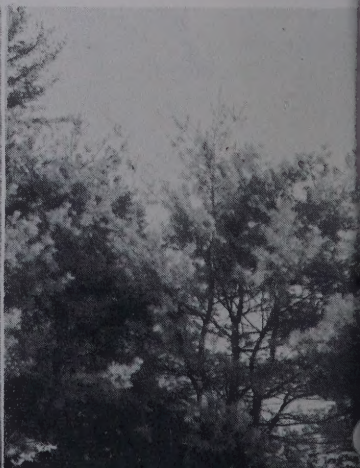


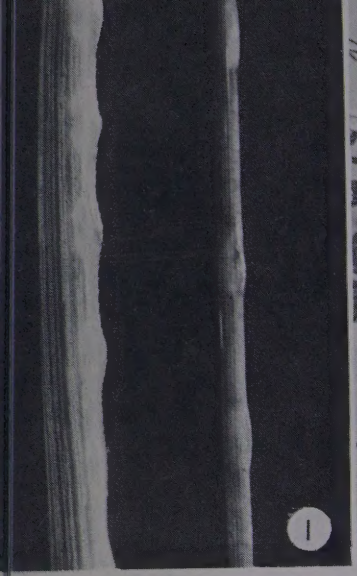
White Pine Weevil

This weevil is a serious hazard to the growth
straight, well-formed white pine. Trees are most susc
tible when growing in plantations or open stands
when 5 to 20 years old. The weevil also attacks wh
and Norway spruce, and red and jack pine. The adult
overwinters in the duff, and in the early spring crawls
flies to the leaders of dominant trees to feed and depo
its eggs. The punctures made in the leader are mark
by exudations of pitch (2). The young larvae feed in
inner bark working down the leader. Pupation takes pla
in the wood or pith (3). Adults emerge in late summer a
feed on the bark of old and new growth before hibernati
Larval feeding causes the new growth to droop (4) a
ultimately the death of the leader (5). Subsequently, o
or more laterals assume leadership (6); repeated attac
produce crooked or multi-stemmed trees of little comm
cial value (7). Direct control measures include remov
of infested leaders, and spraying to prevent ovipositio
Dense plantings, preferably in mixtures or under hardwo
canopies, are cultural techniques to avoid serious inju



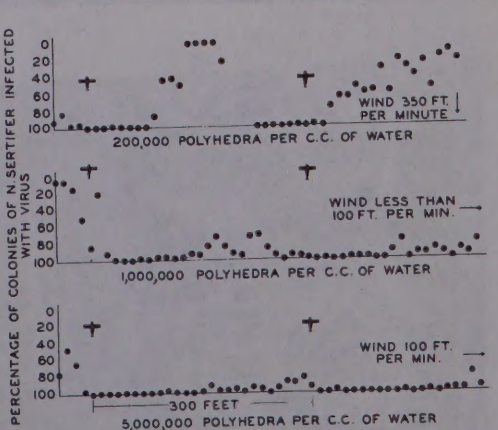


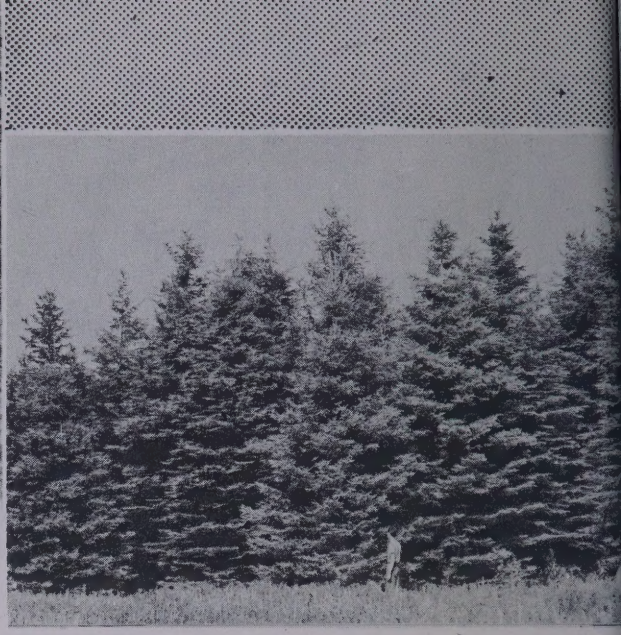




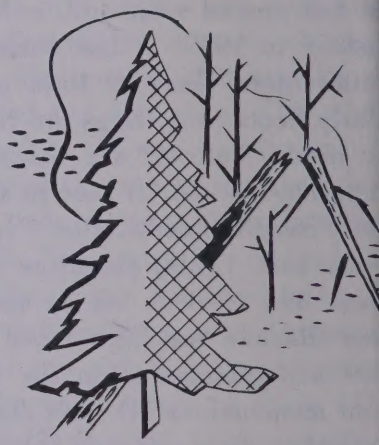
European Pine Sawfly

This sawfly was discovered in New Jersey in 1925 has spread westward, being first found in Canada at dsor in 1939. It has subsequently spread throughout thwestern Ontario. Hard pines are defoliated, parti- arly Scots pine. Eggs are laid in groups in the needles in the autumn, and hatch the following spring. The gregarious larvae (2) feed in May and June and may cause arly complete defoliation (3). Mature larvae spin cocoons the soil. Birds, parasites and small mammals destroy rvae and cocoons but do not exert effective control. A rus disease was introduced to Canada from Sweden in 49 and propagated in the laboratory and plantations. ter suspensions (4) were disseminated by a mist blower and a light aircraft (6). Sprayed colonies begin to e (7) within 10 days. The degree of mortality depends virus concentration and swath width, as determined wind speed and direction (8). Once established the sease persists and spreads.

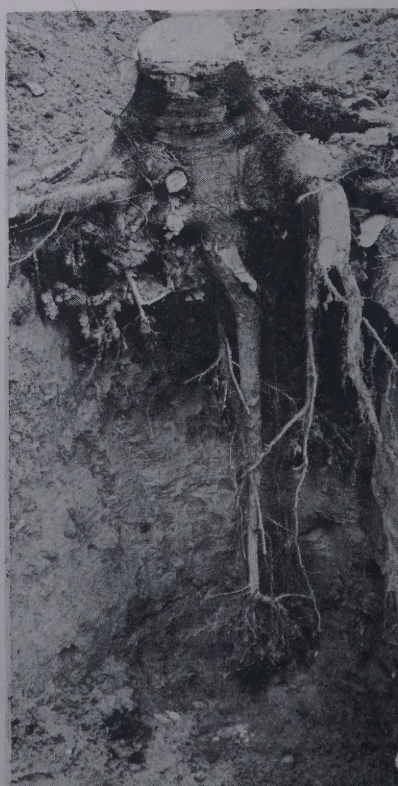


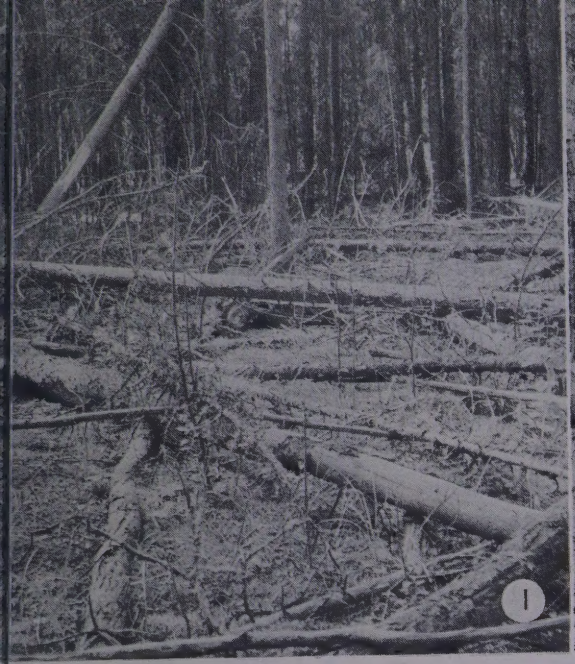


6 Deterioration of White Spruce Plantations



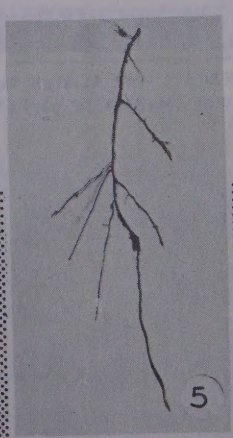
Nutritional and physiological problems arising from unfavourable site conditions are important in the successful growth of plantations. For example, serious deterioration is occurring in 30-year-old plantations of white spruce on sandy soils in Quebec (1). In many places the stocking has been reduced by 80-90 per cent and the volume of the remaining trees is much lower than that of normal healthy trees (2). Stand density and volume are reduced where nutrients are deficient, or made unavailable by extreme temperature and drought. On sandy soils, white spruce trees frequently have superficial root systems and summer temperatures reaching 85° F. are common in the upper two inches of soil. The healthy trees possess tap roots which penetrate to moist soil (4). Thus, these plantations are affected by a complex of factors including climate, physical and chemical factors of the soil, and the root development of the individual trees.

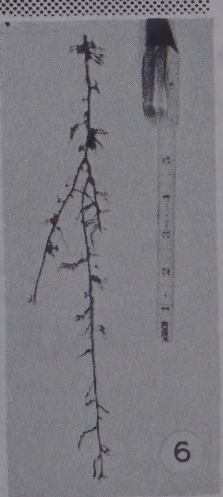




Mortality in Young White Spruce Stands

In the Candle Lake region of Saskatchewan the dying white spruce in patches is resulting in openings of ous sizes in immature stands (1,2). Ecological studies e shown that unfavourable soil conditions occur nin the areas of the stand openings. The soils are hly acid and the B-horizon which is impenetrable for ts is near the surface. Trees within the openings have llow root systems as compared to those on favourable ls (3,4). Considerable mortality occurs in the smaller ts which lack a normal complement of feeder rootlets 5). The trees with root systems weakened in this way predisposed to further injury from root fungi and insects ich later cause mortality.





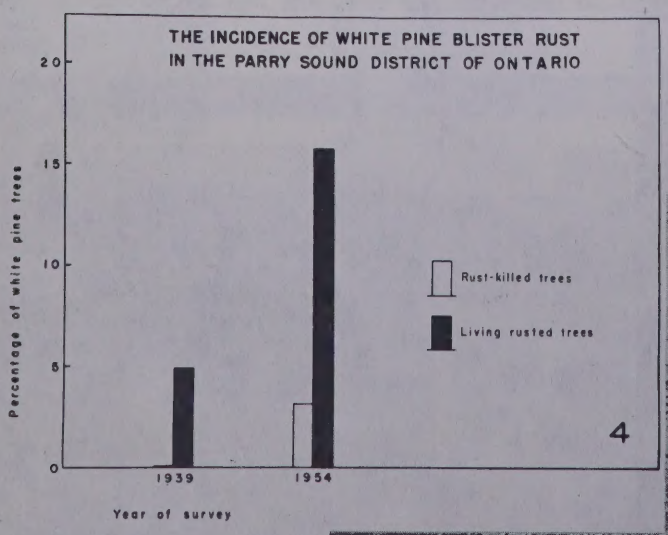
8

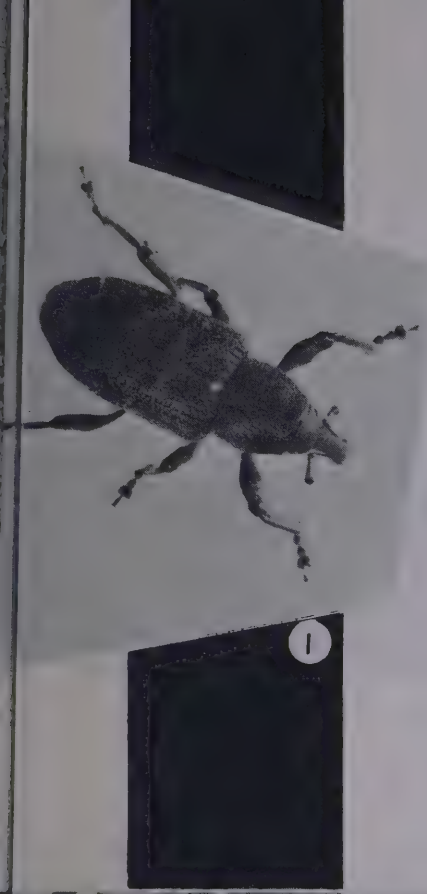
White Pine Blister Rust

Perhaps the greatest menace to the continued production of white pine lumber in Canada lies in the occurrence of an introduced disease, white pine blister rust (1). The fungus which causes this disease alternates between white pine and currants and gooseberries, *Ribes* spp. (2,3).

In Ontario, the spread and intensification of the disease have been observed and recorded over a number of years (4). Surveys have established the regions where white pine blister rust is increasing, and there are areas of high hazard in productive white pine stands. Local control through the eradication of *Ribes* would be possible in these areas. A start on control work has been made in Ontario and Nova Scotia. In the Ottawa Valley region of Ontario studies are in progress on the ecological control of the disease through regulation of stand thinning operations.

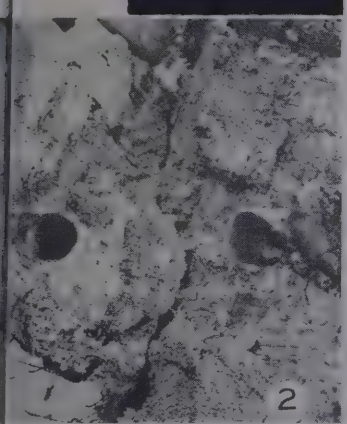
A tree selection and breeding program to obtain strains of white pine resistant to the disease is underway in Ontario and British Columbia (Figure 5 illustrates a disease garden at the Duncan Nursery, Vancouver Island). In Ontario this work is undertaken in cooperation with Dr. C.C. Heimburger, forest geneticist, Ontario Department of Lands and Forests.





9 Pine Root-Collar Weevil

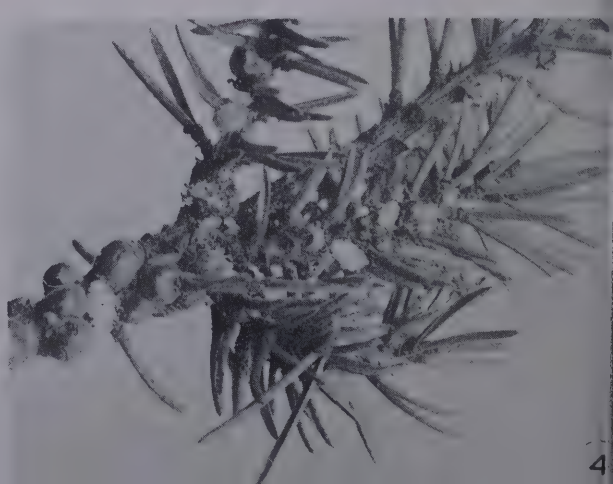
Damage by this insect has occurred in the north-eastern and north-central United States for many years. In the last two years the species was found in severe localized infestations in plantations on sand plains in Simcoe County, Ontario, and in the Sandilands Forest Reserve, Manitoba. Characteristics of attack include faded or discoloured foliage, retarded growth, disproportionally large butts, leaning trees, and resin-soaked soil about the base of the tree. The adult (1) deposits eggs singly in the bark at the root collar. The grubs feed on the inner bark causing a copious flow of pitch. Pupation takes place in chambers formed in the bark and pitch (2). Repeated attack causes the formation of an extensive pitch collar below ground level (3) and a constriction and girdling of the stem (4). Injury may progress to the point where trees can be pushed over before marked symptoms are evident above ground (5). In plantations, Scots pine is more vulnerable than red pine (6). Control is difficult owing to the subterranean habits and to the difficulty of detecting attacks in early stages. Experiments with fumigants and soil insecticides are in progress.

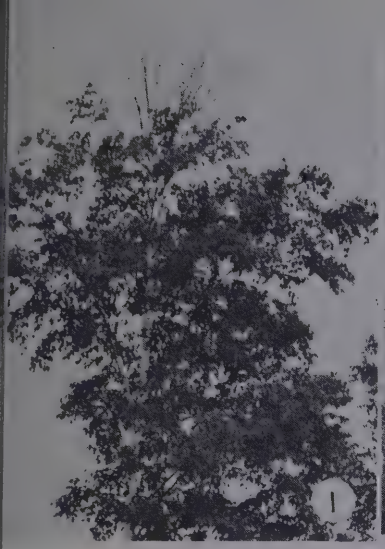


10

Pine Tortoise Scale

Young plantations or natural stands of jack, red, and Scots pines are attacked by this sucking insect. The most severe injury has occurred in the Sandilands area of Manitoba. Continued attacks cause foliage drop, reduction in needle size (1), a general decline in vigour (2), and occasionally death of trees. There is one generation per year. The partly grown sedentary females, which overwinter on the twigs, resume growth early in the spring and produce eggs in June. The young crawlers soon appear and settle down to feed. Male scales (3) mature rapidly and the fragile, winged males fertilize the partly-grown immobile female scales in August. The female scales reach full growth the following year (4). A copious secretion of honey-dew, attendant ants, and a sooty fungus growing on the honey-dew are characteristic of pine tortoise scale infestations. Lady-bird beetles are the most important natural control factor. Malathion sprays are effective on ornamental trees.

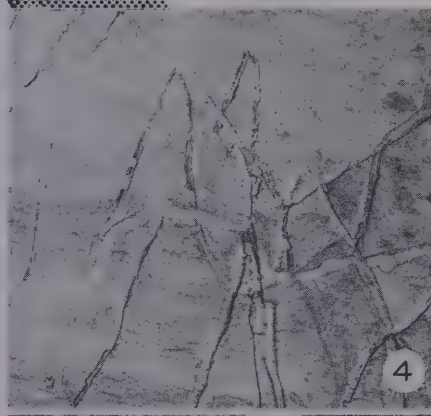




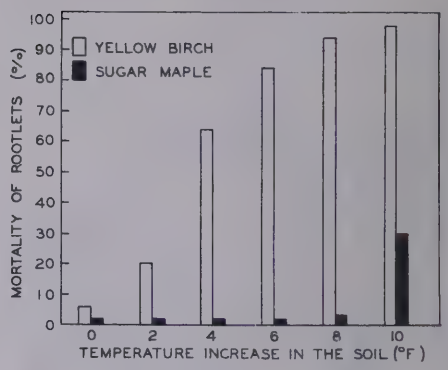
Birch Dieback

Deterioration of birch stands became evident in south-central New Brunswick in the early 1930's, and later through most of the Maritime Provinces, much of Quebec, and the northeastern states. The condition, known as "dieback", was characterized first by small and shrivelled foliage in the top of the tree, death of small twigs and branches (1), then death of larger branches and the tree (2). Heavy mortality occurred by the mid-1940's (3). Improvement of surviving trees was rapid in the late 1940's.

The bronze birch borer (4) and mildly parasitic fungi in the tops and roots of affected trees contributed to their further decline, but were not the primary cause of the injury. Increasing rootlet mortality and fewer mycorrhiza occurred in trees in successively advanced stages of dieback (5,6). High temperatures and low precipitation during established stress periods for moisture were associated with the injury. The bulk of the evidence to date has supported the view that the disease was caused by climatic changes, but the possibility that a virus was involved is now being re-examined.



RELATION BETWEEN MORTALITY IN YELLOW BIRCH AND SUGAR MAPLE ROOTLETS AND INCREASE IN SOIL TEMPERATURE THROUGHOUT THE GROWING SEASON.



2

Ecology and Physiology of Trees

Disease and insect injuries produce abnormalities in trees, the full significance of which can be understood only by a knowledge of normal form and function. In the discussion of the birch dieback problem reference was made to the influence of climate. In artificially heated forest soil (1) it was found that yellow birch rootlets are more sensitive to temperature increases than those of sugar maple (2). The latter species showed no widespread natural deterioration comparable to that in birch, though frequently growing in the same stands. In studies of movement and storage of water in relation to anatomy and cell structure of woody stems, successive transverse cuts more than half way through the stem (3), followed by injection with a stain below the lowest cut, did not prevent the uptake of moisture. The inset charts outlining the stain patterns immediately above the fourth saw-cut in treated sugar maple and American elm trees illustrate a continued uptake of water despite the drastic interruption of conducting tissues.

3

The consequences of insect defoliation are variable, depending on the tree species, the time of seasonal defoliation, and the age of foliage removed. To provide an explanation of the varied consequences, studies are being carried out on the photosynthetic capacity of foliage produced in different years, and changes with aging during the first season (4,5).

4

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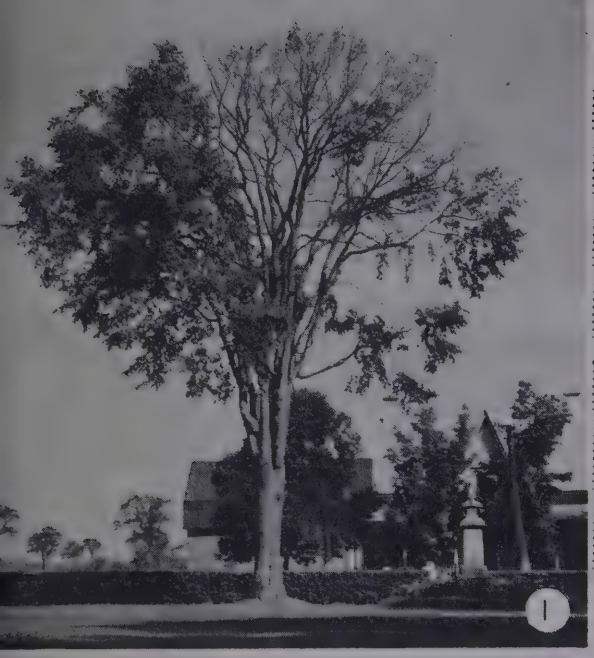
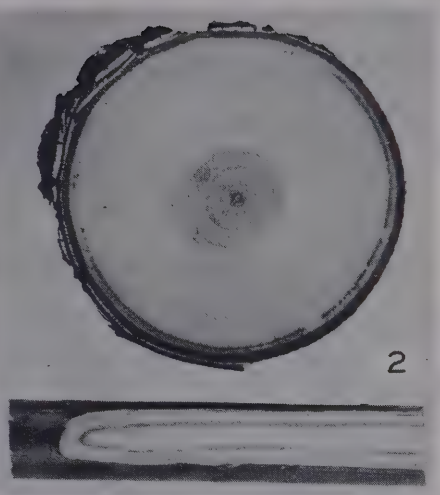


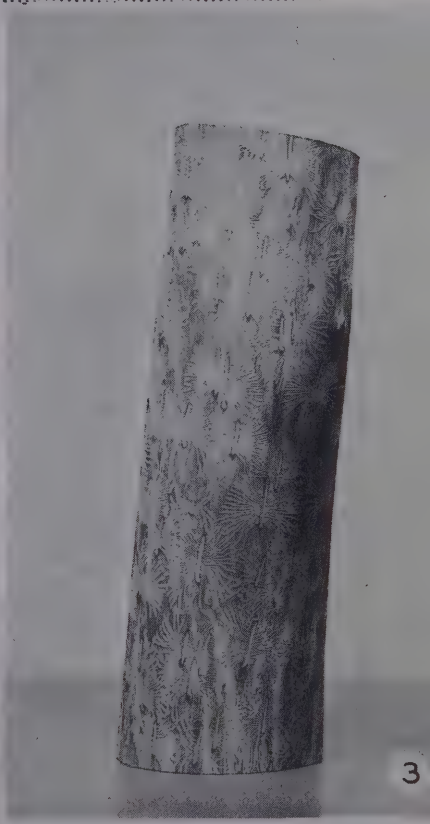


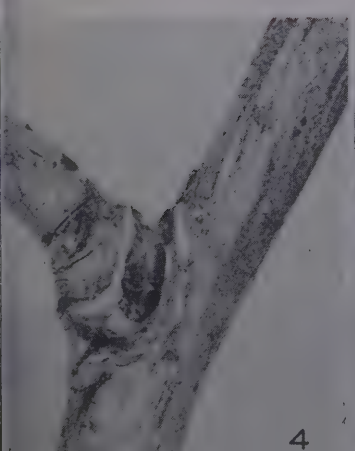
13

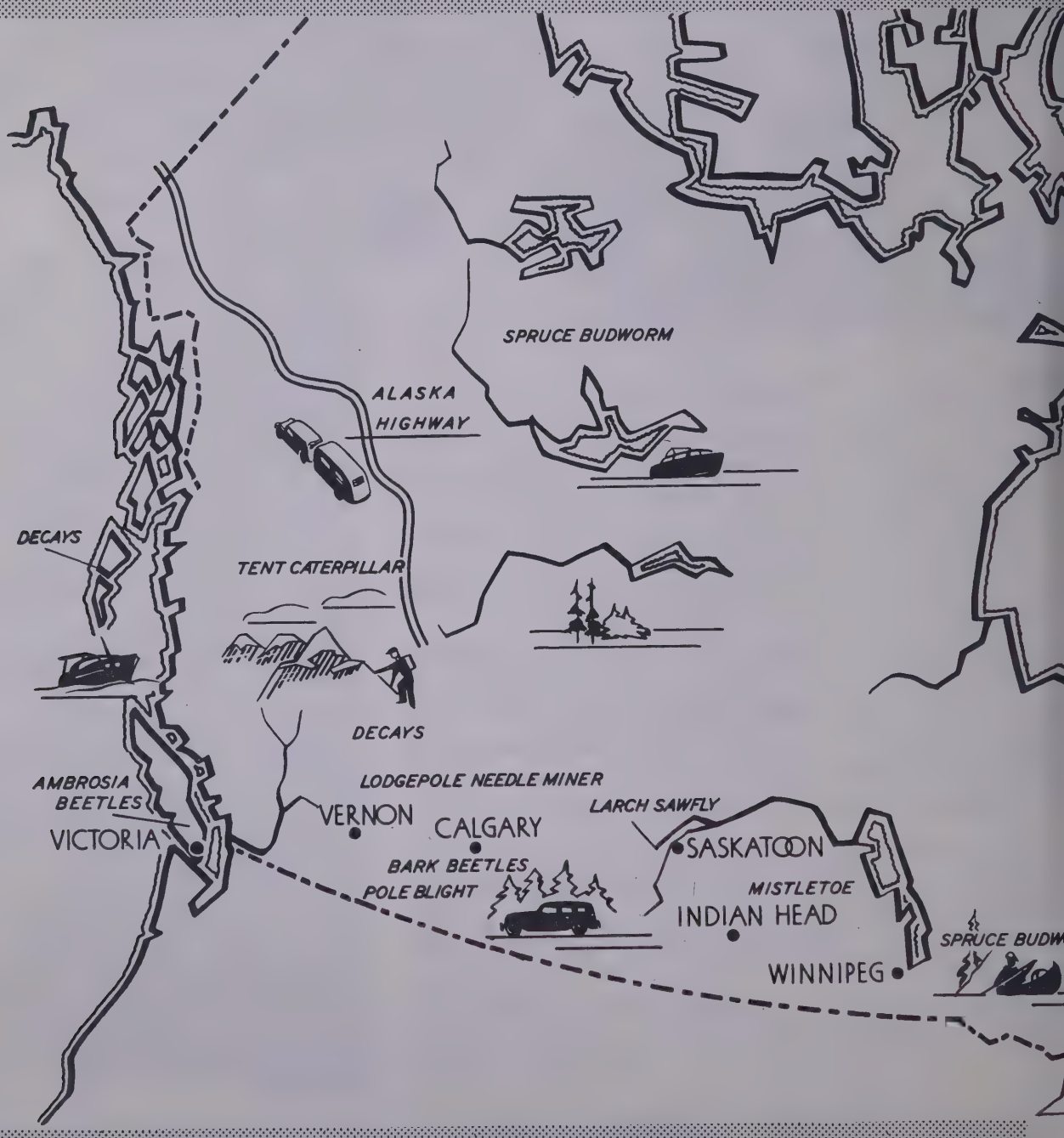
Dutch Elm Disease

This wilt disease (1) of foreign origin was first found in Canada in 1944 and is now firmly established in the St. Lawrence and the lower Ottawa River valleys in Quebec. It has also been found sporadically across southern Ontario, being particularly serious in the vicinity of Windsor. The causal fungus develops in the water-conducting vessels of the sapwood (2). The dead and dying host tissue is attacked by the native and European elm bark beetles, and the fungus continues to grow, producing spores in the insect galleries (3). The sticky spores adhere to the emerging beetles and are transmitted to other elm trees when the beetles enter the bark to feed (4) or to establish brood tunnels.

A thorough application of a DDT spray to the trunk of a healthy tree will prevent beetles from entering and introducing spores of the causal fungus. Similar treatment of diseased trees will prevent beetles either from entering or emerging (5). In Europe, the United States, and Quebec attention is being given to the selection and breeding of resistant strains of elm (6).



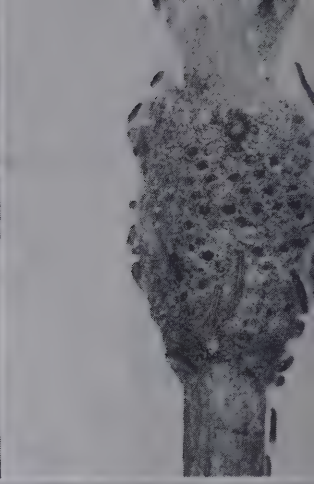



SPRUCE BUDWORM
ALASKA HIGHWAY
DECAYS
TENT CATERPILLAR
DECAYS
AMBROSIA BEETLES
VICTORIA
LODGEPOLE NEEDLE MINER
VERNON
CALGARY
LARCH SAWFLY
SASKATOON
BARK BEETLES
POLE BLIGHT
MISTLETOE
INDIAN HEAD
WINNIPEG
SPRUCE BUDW

Forest Insect and Disease Survey

The survey of insects affecting Canadian forests has been in progress for nearly 20 years. In 1951, a survey of tree diseases was included in the program. In addition to assessment of current infestations and disease incidence, summarized in the Annual Report of Forest Insect and Disease Survey, the objectives of the Survey comprise a basic understanding of forest insects and diseases, eg. general habits and life histories, immature stages, geographical distribution, host trees, and natural control factors.

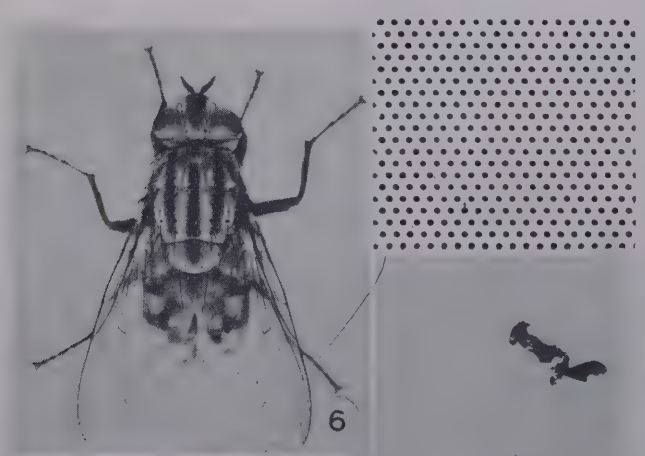
The 11 regional Survey centres extend from Corner Brook, Nfld. to Victoria, B.C. Field work is accomplished by about 75 permanently employed rangers with the co-operation of other agencies. Rangers are assigned to specific districts which vary greatly in size, forest conditions, accessibility, and insect and disease problems. Some places where insect and disease problems are of particular importance at the present time are shown on the map.

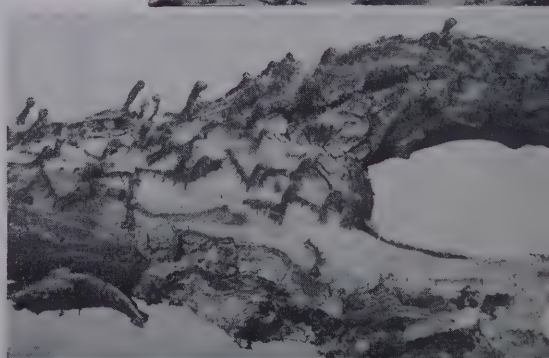


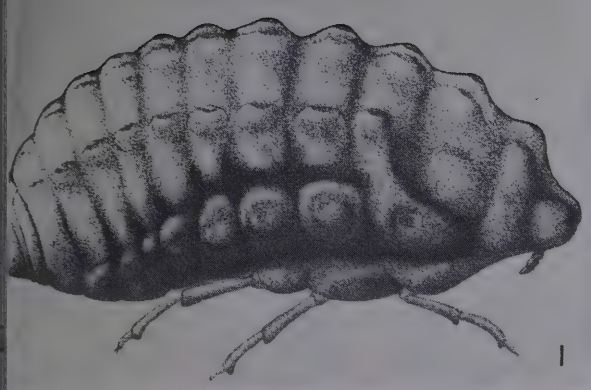
16

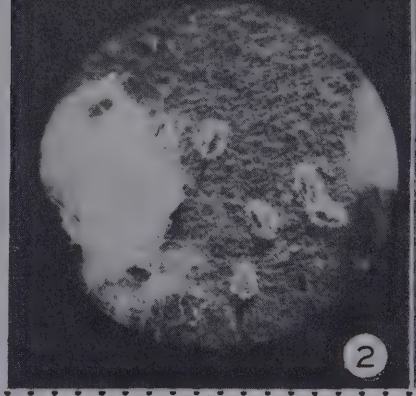
Forest Tent Caterpillar

This insect occurs throughout Canada and feeds upon various deciduous trees, but prefers aspen. In periodic outbreaks thousands of square miles of deciduous stands may be completely stripped in late May or June (1,2). The insects overwinter as eggs clustered around a twig (3). The caterpillars hatch on warm days in late April or May and feed on young leaves (4). When very abundant they eat the foliage as fast as it appears and often must wander in search of additional food. Unlike closely related species, the caterpillars do not make "tents" but are often found clustered on tree trunks (5). Infestations persist in any one area for three or four years, finally collapsing from various causes, including parasites (6), virus diseases (7), fungous diseases (8), starvation, and unfavourable weather conditions, particularly in early spring. Stripped trees refoliate in late summer and may survive four or five years' attack. Ring growth, however, is greatly retarded (9). Insecticides, when properly applied, are effective around buildings and in populated areas.





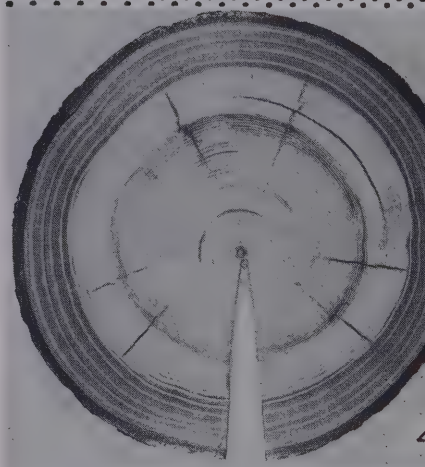




17

Balsam Woolly Aphid

This minute sucking insect of European origin causes serious damage to balsam fir in the Maritime Provinces. Although related species have successive generations alternating between spruce and other conifers, the balsam woolly aphid affects only balsam. The trunks, branches and shoots are attacked by two wingless generations each year. An adult, cleared of the typical white waxy threads, is shown in Fig. 1, and larvae in Fig. 2. Heavy stem attacks (3) cause the production of reddish-brown brittle wood (4), and frequently the death of trees within three or four years. Feeding on the shoots causes thickened nodes (5), a condition termed "gout disease", and eventually the death of twigs and tops (6). Infestations are most serious in coastal areas owing to the more moderate climate, since overwintering larvae are killed by temperatures below -30° F unless protected by snow cover. Parasites are entirely lacking and native predators ineffective. Predacious insects have been imported from Europe by biological control agencies, and establishment, dispersal, and effectiveness are being studied intensively (7,8).



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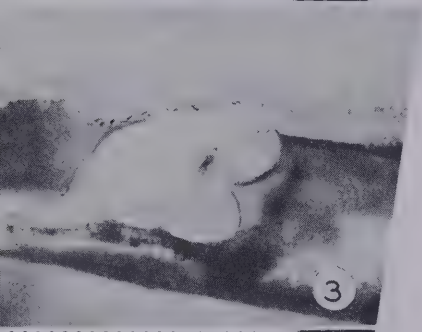

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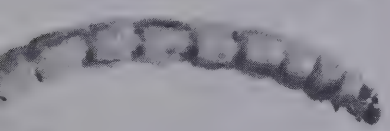

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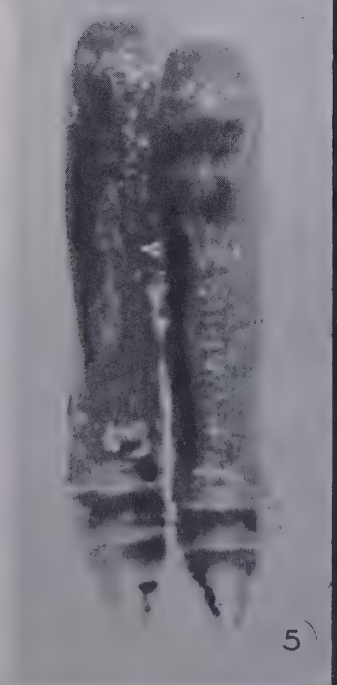

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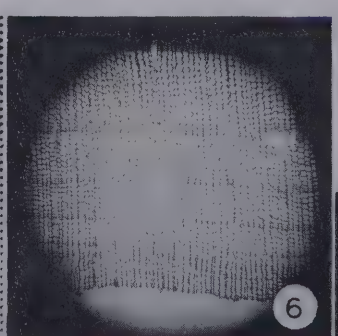

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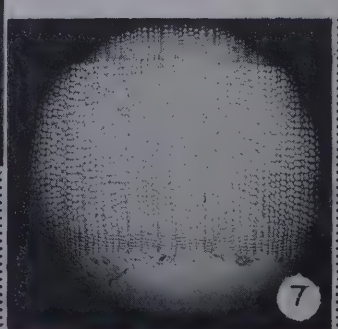

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Lodgepole Needle Miner

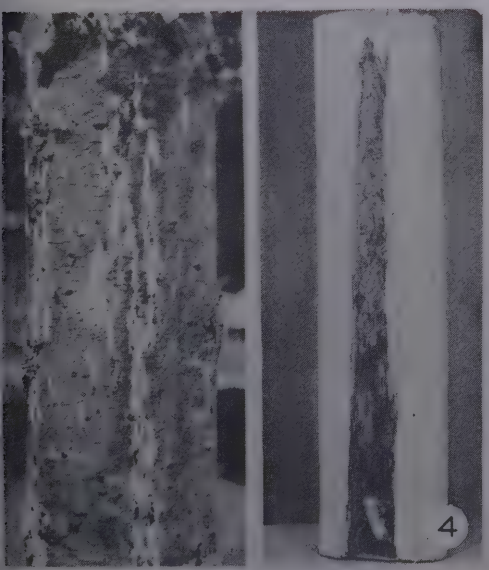
Since the early 1940's, lodgepole pines in the Banff-Jasper area of the Canadian Rockies have been attacked by this minute insect. The moths (1,2) appear in even-numbered years and lay eggs (3) in mid-summer in old larval mines, on the needles, or on the sheath. Larval development extends from late summer of that year to June or July of the next even-numbered year. Each larva mines a series of three needles within the last of which the fullgrown larva (4) transforms to the pupa (5). Injury is most conspicuous in June and July of flight years when old mined needles are reddish-brown and newly mined needles are bright yellow. Up to 90 per cent of the needles may be affected. Parasites usually account for about 30 per cent of the population. Winter mortality is occasionally severe in vally bottoms which, however, are repopulated by moths from the slopes. Despite repeated attack, no trees have yet been killed although tree vigour has been much reduced as shown by growth of infested (6) and uninfested (7) trees. There is a danger that weakened trees may be attacked by the mountain pine beetle.

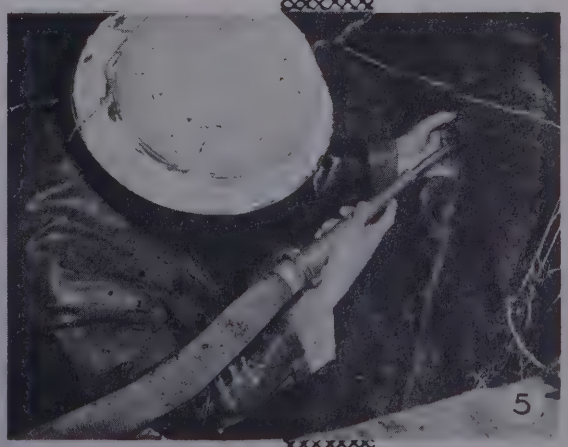
19

Pole Blight of Western White Pine

Pole blight, a disease of unknown cause, results in the general decline and mortality of western white pine 40 to 100 years of age (1,2,3). It was first reported in British Columbia in 1948, and in 1949 surveys demonstrated that the disease was distributed throughout the commercial range of the host in the Interior; in some areas 45 per cent of the trees were affected.

Stem lesions of fungal origin occur commonly on trees with pole blight (4). Inoculations on healthy trees resulted in lesions but not in symptoms of pole blight. It is felt that this fungus is not the primary cause of the disease. In cooperation with the British Columbia Forest Service, experimental thinnings were made to remove the diseased trees in the hope of offering protection to the residual stands. Over a 3-year period the thinnings have been ineffective in retarding the progress of pole blight. Root excavation and laboratory research are in progress to determine the structural and ecological characteristics of the roots of healthy and diseased trees (5), and the fungi and insects associated with them.





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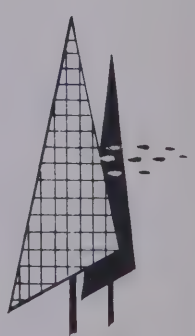
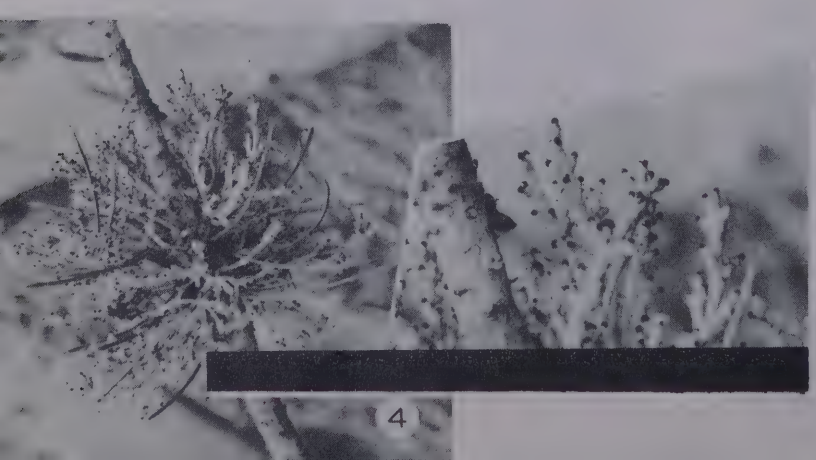
Dwarf Mistletoes

In Saskatchewan, Alberta, and British Columbia, dwarf mistletoes cause heavy losses in coniferous trees. Attack results in reduced rate of growth, weakening to the extent that wood-destroying fungi attack the tree (1), and frequently in death (2). Infected trees become deformed through the development of stem swellings which lower timber quality. Small, yellowish-green shoots of the mistletoe plant develop on infected trees (3).



Until recently it was considered that forms of dwarf mistletoe were host specific, for example, the form on lodgepole pine would not infect white spruce. Control operations have been made to remove the diseased pine from mixed stands of lodgepole pine and white spruce. Current biological studies have demonstrated that the pine form may spread to white spruce, thus altering the previous concepts in regard to this method of control. Two fungi have been found to be parasitic on mistletoe shoots, and may be effective in limiting the spread (fungus evident as black spots on the ends of the mistletoe shoots in Figure 4). Research is being directed to this as a possibility for biological control and also to selective herbicides which would kill the mistletoe plants without injuring the host trees (5).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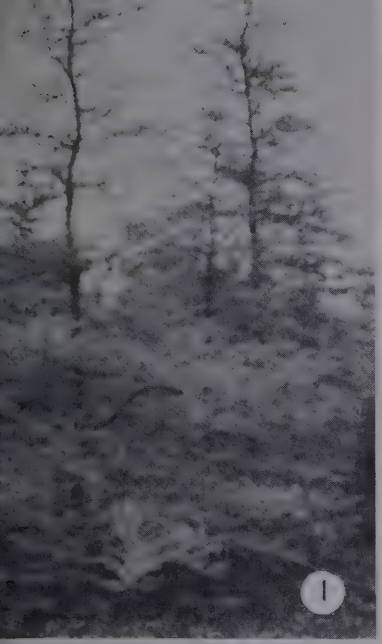
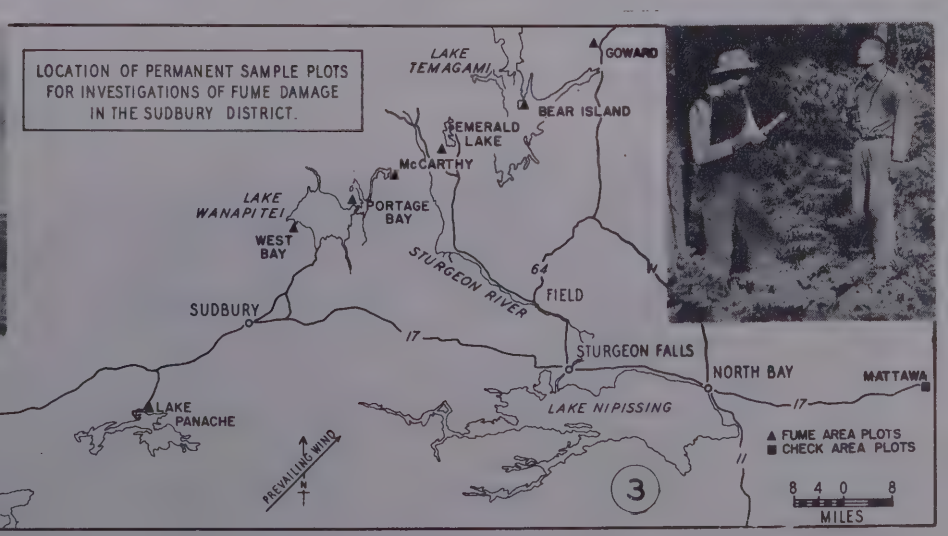


21

Fume Injury

Frequently the smoke emitted from industrial plants contains poisonous gases which cause injury to the adjacent forests (1,2). An example of this type of problem occurs in the Sudbury district of Ontario where the smelting of nickel and copper sulphide ores causes injury to neighboring stands of timber through the emission of sulphur dioxide to the atmosphere. This problem is of particular importance because some of the most valuable pine stands in the Province occur within the suspected zone of injury. Investigations are in progress to provide an accurate definition of the area affected and to assess the degree of damage at increasing distances from the fume sources. These include studies on reproduction, increment, mortality, and stand composition. The results of studies on permanent sample plots during the last 5 years have determined, in part, the areas affected by smelter fumes. Injury is known to occur at distances of from 25 to 30 miles northeast of the Smelters in the direction of the prevailing wind (3).



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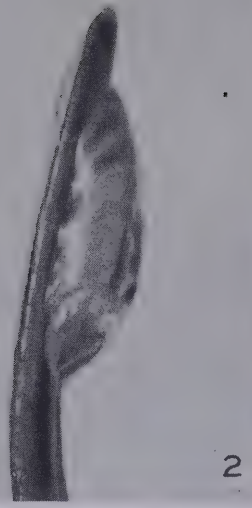

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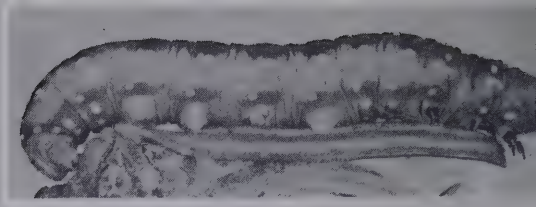
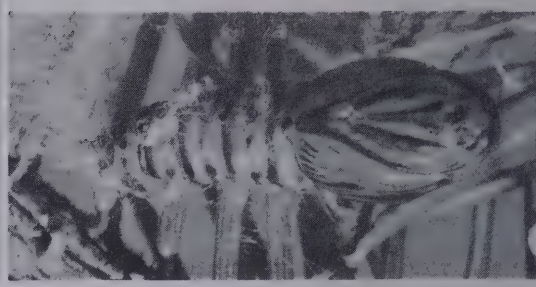




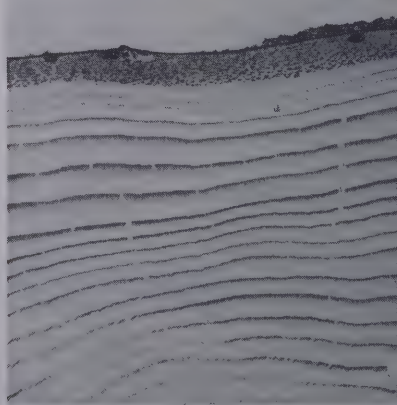
22

Spruce Budworm

This insect is the most destructive enemy of balsam-spruce forests of Eastern Canada. It is also present in Western Canada but no important tree mortality has occurred. The moth (1) deposits eggs on the needles (2) in mid-summer. The young larvae hibernate on the tree. The following spring they mine needles or male flower buds and transfer to the new growth as it develops. New foliage is preferred but late-stage larvae (3) can subsist on old needles. Pupae (4) occur on the twigs in late June and July, and produce moths shortly afterwards.

Repeated attacks destroy buds and twigs (5) and reduce increment (6); if continued five or more years, death results (7). Spruce is less vulnerable than balsam and records the history of infestations in the ring pattern (8). Dry weather cycles favour outbreaks in mature and overmature balsam stands. In epidemics, parasites, predators and diseases are incapable of preventing serious damage. Increased utilization of mature stands of balsam fir will reduce the long-term hazard. Large-scale spraying operations (9) in New Brunswick and Quebec are designed to prevent destruction of valuable stands. The DDT sprays have reduced budworm populations and preserved new foliage (10). The long-term effects will not be known for several years.

(Fig. 9, through the courtesy of Forest Protection Ltd. and J. Stone, photographer.)



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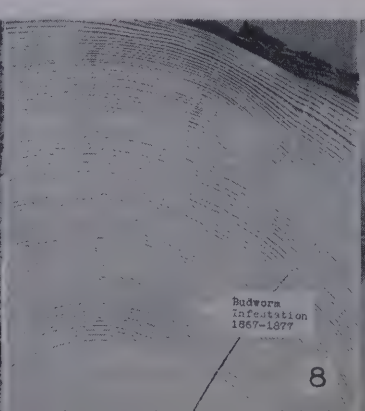

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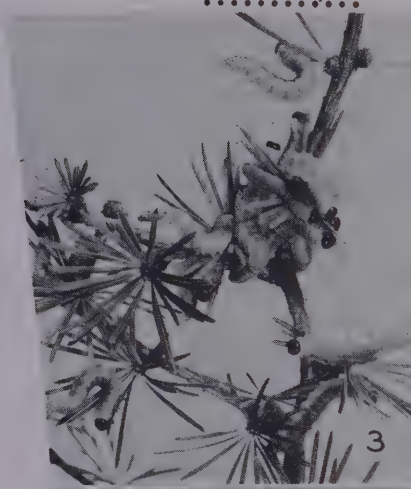
Larch Sawfly

This sawfly, presumably of European origin, is established in tamarack stands from Newfoundland to northern British Columbia, and on western larch in the southern interior of the latter province. Females (1) cause distinctive twig curling (2) through laying eggs in slits cut into the new shoots. The gregarious larvae (3) feed upon the fascicles of needles and when full grown drop and spin cocoons in the moss or duff where they overwinter. Trees may be completely stripped (4,5) but, if vigourous, can survive successive defoliations although shoot production and radial increment are much reduced (6). Widespread mortality of mature trees occurred about 40 years ago in a severe outbreak.

Various predators, parasites, and diseases attack the sawfly both on the tree and in the ground. High water-levels cause cocoon mortality. Late in an outbreak, starvation and reduced fecundity become important. A European parasite, introduced 45 years ago, has been very effective, but recently the sawfly has developed a resistance to the parasite in the central provinces. This resistant strain encapsulates the parasite eggs. A search for effective natural controls is in progress. Larvae are susceptible to insecticides but the oviposition period is long, thereby lessening the effectiveness of single applications.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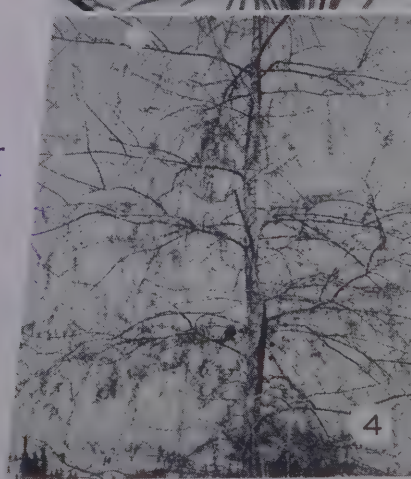
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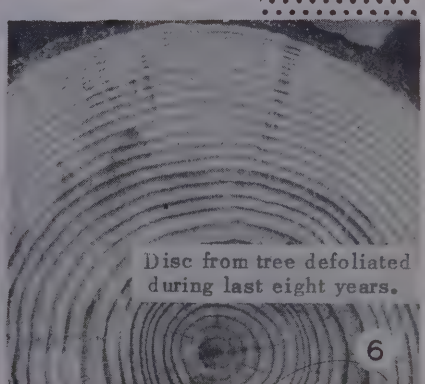
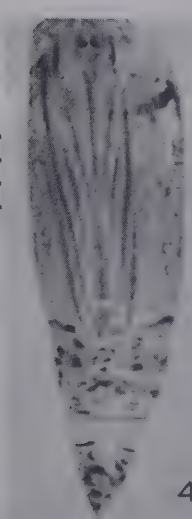

Disc from tree defoliated during last eight years.
6

Hemlock Looper

The hemlock looper has killed balsam fir stands in Newfoundland, Quebec North Shore, Gaspe, and the Abitibi area of Ontario. Severe infestations causing some mortality of eastern hemlock have occurred in the Thousand Islands and Muskoka areas of Ontario. Heavy mortality of western hemlock and associated species has occurred in coastal and interior wet belt areas of British Columbia. The moths (1) are conspicuous in late summer and early autumn. Eggs (2) are laid on all parts of the tree and hatch the following spring. Larvae (3) feed wastefully destroying more foliage than they consume. Larvae when young are dependent on new foliage of their host trees, but later can feed on other conifers and a variety of deciduous trees and shrubs. Pupae (4) are found from the topmost twigs to the forest litter. Infestations are intense, of short duration, and strongly localized. Severe mortality (5) may be caused by one or two years' defoliation. Aerial spray operations are a practical control measure but effective planning must follow the first evidences of marked population increases if tree mortality is to be prevented.



Decay Problems

Forest land has a potential maximum yield which may be achieved with an optimum stocking at the age of maturity. In overmature forests this yield may be greatly reduced by wood rots (1,2,3). Ultimately in evenaged stands or in the old surviving trees in overmature stands an age is reached when the decay increment exceeds the growth increment, resulting in non-productive stands or trees. In evenaged stands approaching maturity it is necessary to determine a pathological rotation which will provide the greatest recovery of sound wood (4). In overmature forests it is necessary to determine the percentage of the commercial volume which is comprised of non-productive trees for the establishment of priority of cutting on a stand basis. This percentage will vary with the stand and age since the amount of decay will be dependent upon such factors as forest composition and site.

The forest industry in Canada has been operating largely in mature and overmature stands, in which heavy decay losses have occurred. However increased utilization of diseased trees is frequently possible owing to their content of sound, high-grade wood (5). Knowledge of decays, which are commonly hidden, and their development is important in the preparation of accurate inventories. The importance of decay studies to forest management has been recognized and the procedures developed as the result of pathological research are now being applied by industry and the British Columbia and the Ontario Departments of Lands and Forests. Biological and ecological studies of fungi responsible for decay are being continued.

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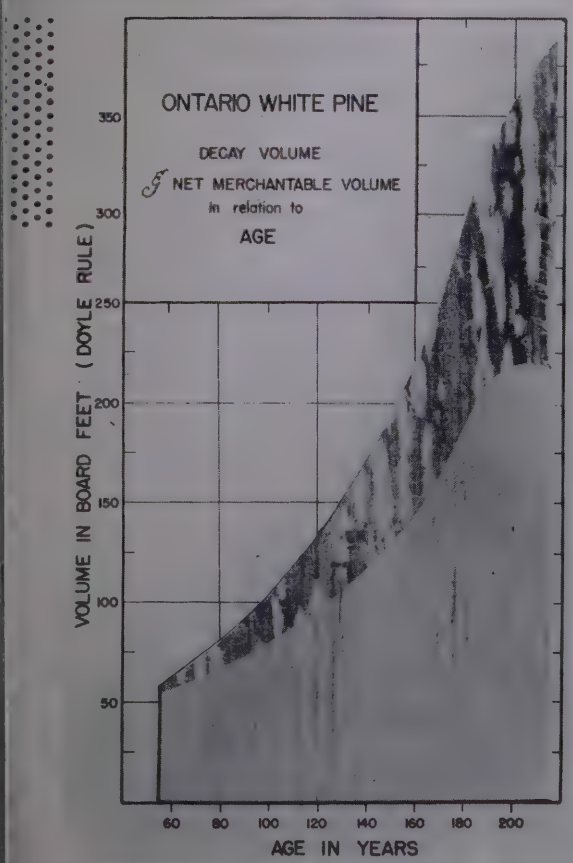

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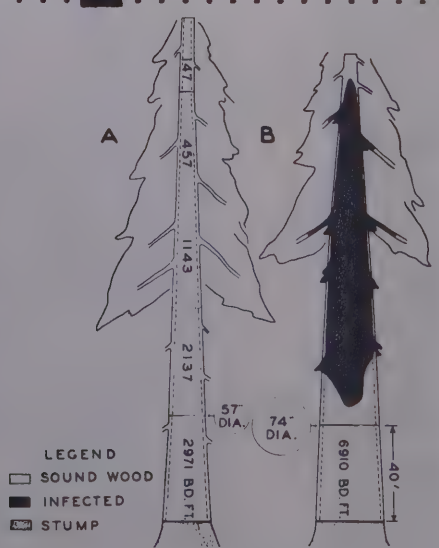


CONK ROT IN SITKA SPRUCE ON THE QUEEN CHARLOTTE ISLANDS

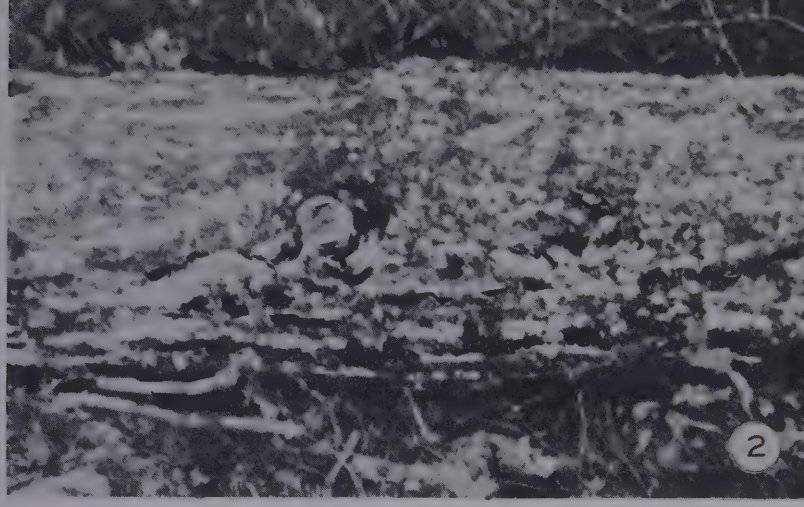
5

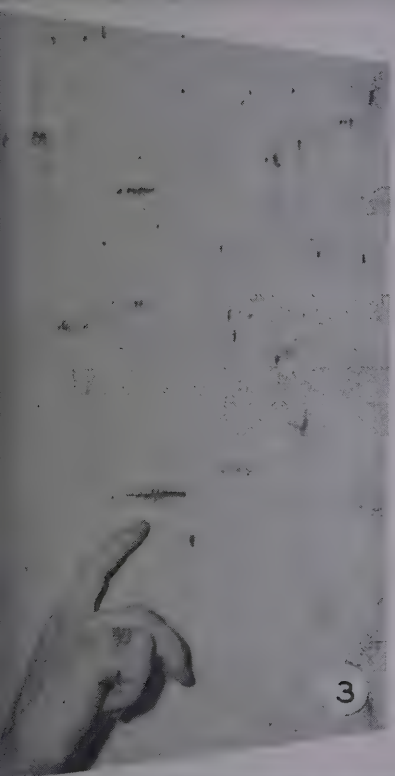
26 Douglas Fir Beetle

This beetle is a serious pest of Douglas fir in British Columbia. Large quantities of mature timber are killed in chronic, patch-like infestations (1). Many infestations result from build-up in slash, culls or windfalls but some apparently develop in trees of low vigour. The beetles (2) make brood galleries between the bark and the wood (3). Girdling by larval mines and clogging of conducting tissue by bluestain fungi cause death of the tree. Attacks occur in May or July and there is considerable overlap in development as shown by cage experiments (4) and the typical life history (5).

Elimination of slash, rapid ulilization of infested trees, and felling and burning are methods of control. Studies are in progress on the recognition of beetle-susceptible trees. Their removal by selective logging would reduce hazard.

OVER-WINTERING	MAY	JUNE	JULY	AUG.	SEPT.	REMARKS
CALLOW ADULTS 1951-52	EGGS (FIRST BROOD)					
		LARVAE				
			PUPAE			
				ADULTS		CALLOW ADULTS OF FIRST BROOD OVER-WINTER, SUBSEQUENT BEHAVIOUR SIMILAR TO THAT OF PARENTS.
	(SECOND BROOD, PARENTS DIE AFTER LAYING EGGS)		EGGS			
				LARVAE		SECOND BROOD LARVAE OVERWINTER
LARVAE 1952-53	LARVAE					
		PUPAE				ADULTS OVERWINTER TO DEPOSIT SECOND BROOD OF EGGS IN 1954.
			ADULTS			
	(FIRST BROOD)		EGGS			LARVAE OF FIRST BROOD OVERWINTER, SUBSEQUENT BEHAVIOUR SIMILAR TO THAT OF PARENTS.
				LARVAE		
PARENT ADULTS 1953-54	EGGS					
		LARVAE				
			PUPAE			
	(SECOND BROOD, PARENTS DIE AFTER LAYING EGGS)				ADULTS	CALLOW ADULTS OVER-WINTER, TO PRODUCE TWO BROODS OF EGGS IN 1955, SIMILAR TO CHART FOR 1952.

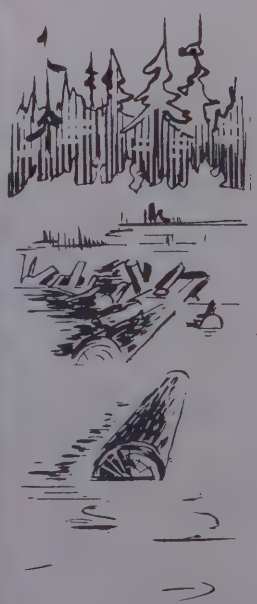




Ambrosia Beetles

In coastal British Columbia, recently-killed trees and logs left in the woods during the summer are liable to severe attack by ambrosia beetles. Early in the spring, one of the most common species (1) attacks logs, particularly Douglas fir and hemlock, felled the previous fall and winter. White boring dust (2) is extruded from the branching galleries which reach a depth of three or four inches. The beetles and larvae feed on a fungus, "ambrosia", which grows in the galleries. The holes and fungous stain (3) produce serious defects in veneer and other quality products.

Milling by late April or May to avoid attack and injury is not always possible. Protection of valuable logs in water storage (4) or in log decks may be provided by benzene hexachloride sprays, although further research is necessary to explain the variable results of recent experimental and commercial control operations.



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Sawyer Beetles

Sawyer beetles (1) cause extensive damage to coniferous logs and dead and dying timber. The adults feed in early summer upon the bark of twigs and may produce flagging. Eggs are inserted in slits gnawed in the bark. Larvae feed between the bark and wood, and form broad winding galleries (2). Later, they make oval holes into the wood where they feed late into the fall and the following spring. Large larvae (3) make tunnels about ¼-inch in diameter which extend deep into the wood (4). Fine wood chips from the galleries accumulate at the base of trees (5) or under infested logs. Pupation occurs at the end of the recurved gallery and adults emerge through circular exit holes. The life cycle is usually two years, but may be of shorter duration in fire-killed timber. Borer holes and associated sap stain (6) rapidly reduce the value of infested timber. Occasionally larvae continue development in sawn lumber (7).

Prompt salvage of killed timber and movement of logs from the woods before early summer are means of avoiding heavy losses. Water storage of logs will also prevent attack. Log skidways can be protected by early season sprays of DDT or benzene hexachloride.

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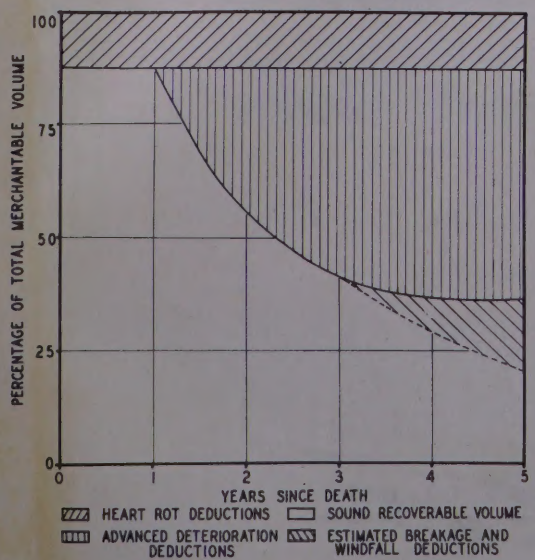
Deterioration

Large areas of forest are frequently killed as the sult of fire, insects, or windstorms (Figure 1 - windthrow Newfoundland). Studies are made to determine the rate deterioration of killed stands in order that valuable mber may be salvaged before insects and decay make ich an operation unprofitable. After the trees are killed ey are attacked by a number of bark- and wood-inhabiting sects. Stain- and sap-rotting fungi enter the trees soon ter the initiation of borer attack (2). Figure 3 illustrates the progressive deterioration of balsam fir killed by the ruce budworm in the Lake Nipigon region of Ontario.

In Alberta the deterioration of lodgepole pine slash important in relation to fire-hazard and the establishent of reproduction. Studies are underway to determine e rate of deterioration of slash under different methods cutting. To date discouraging results have been obtained om efforts to hasten deterioration through the artificial oculation of slash with decay fungi (4).



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